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(71) Applicant
Leeds & Northrup Limited
Wharfdale Road
Tyseley
Birmingham
B11 2DJ
United Kingdom
(72) Inventor
Roger David Edwards
(74) Agents
Reddie & Grose

(54) Thermal printing device

(57) In known thermal printing devices isolating diodes, or other means, have to be used to prevent sneak currents flowing in non-selected heating resistors in a print head and connected in an energising matrix. In the present invention the construction of the print head is simplified by allowing the sneak currents to flow but arranging that temperatures generated by sneak currents are insufficient to mark the paper, whereas the temperature of a selected resistor is sufficient to make a mark.

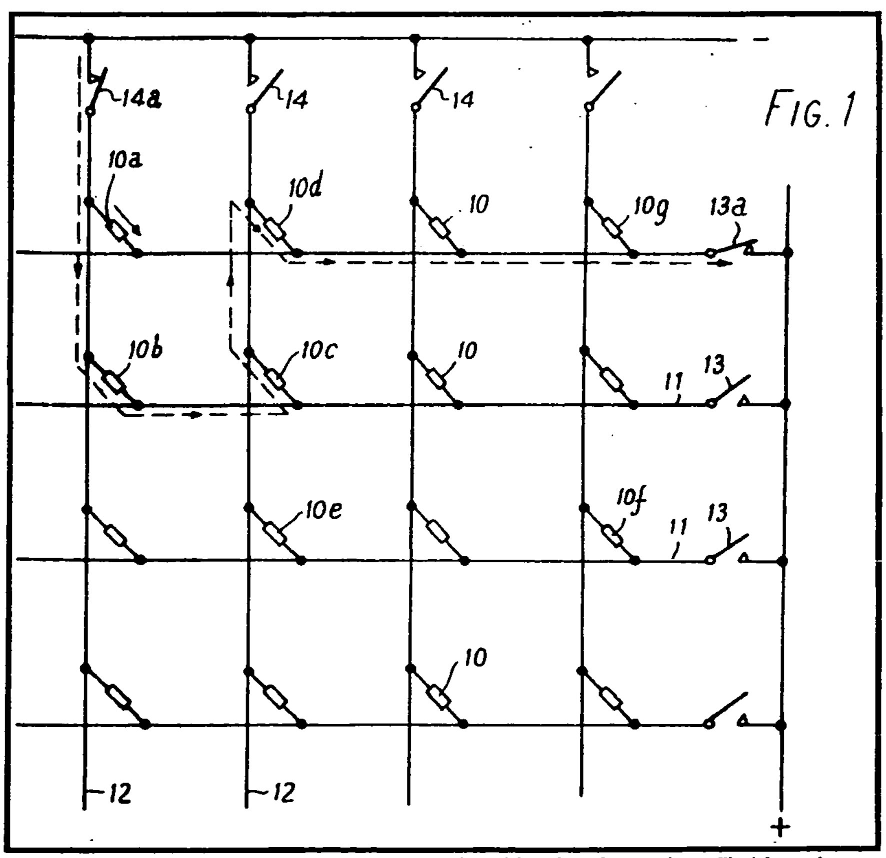

FIG. 1

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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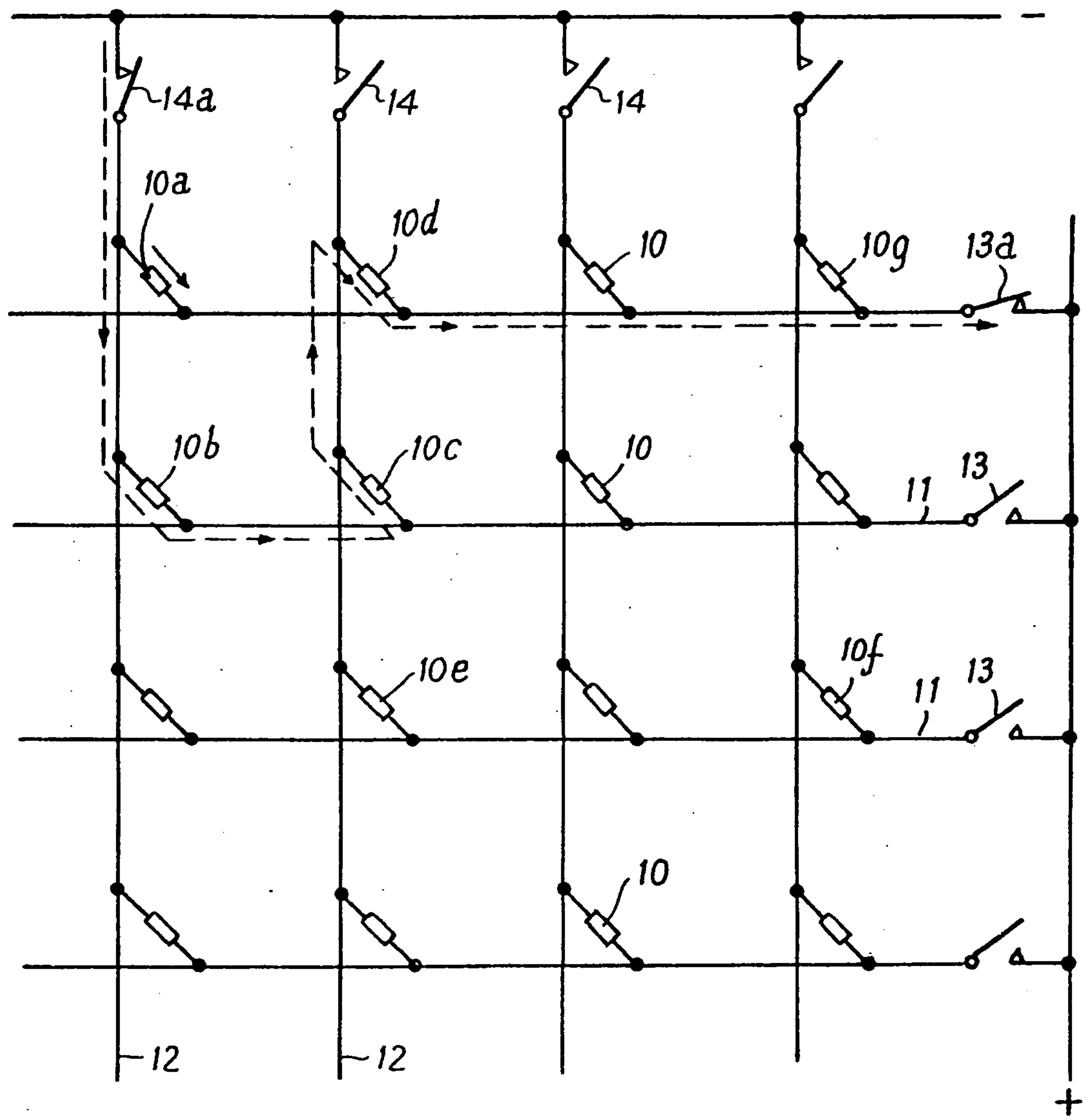
FIG. 1



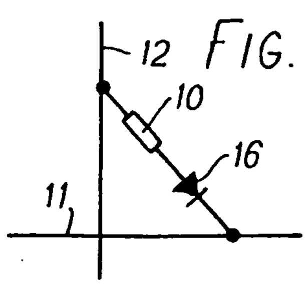


FIG. 2

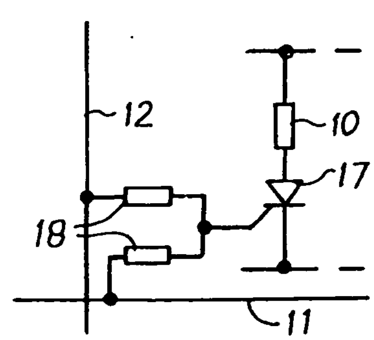


FIG. 3

FIG. 4

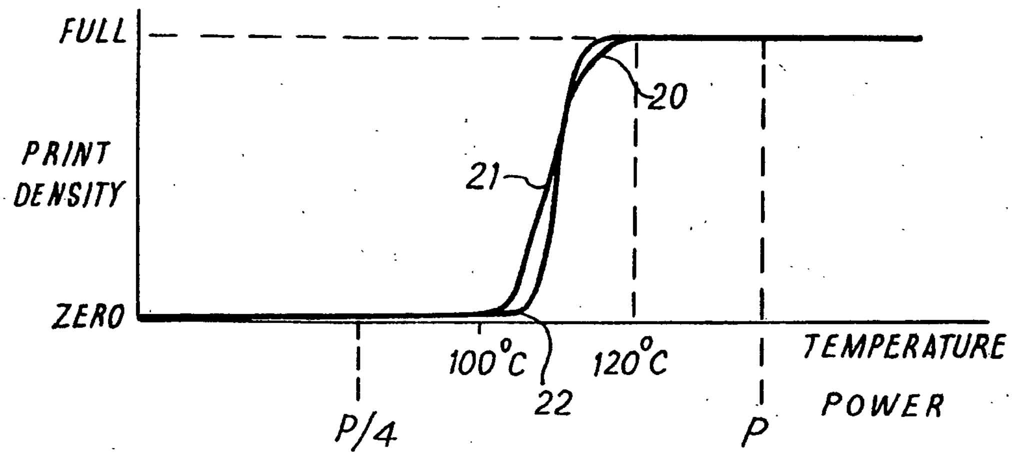
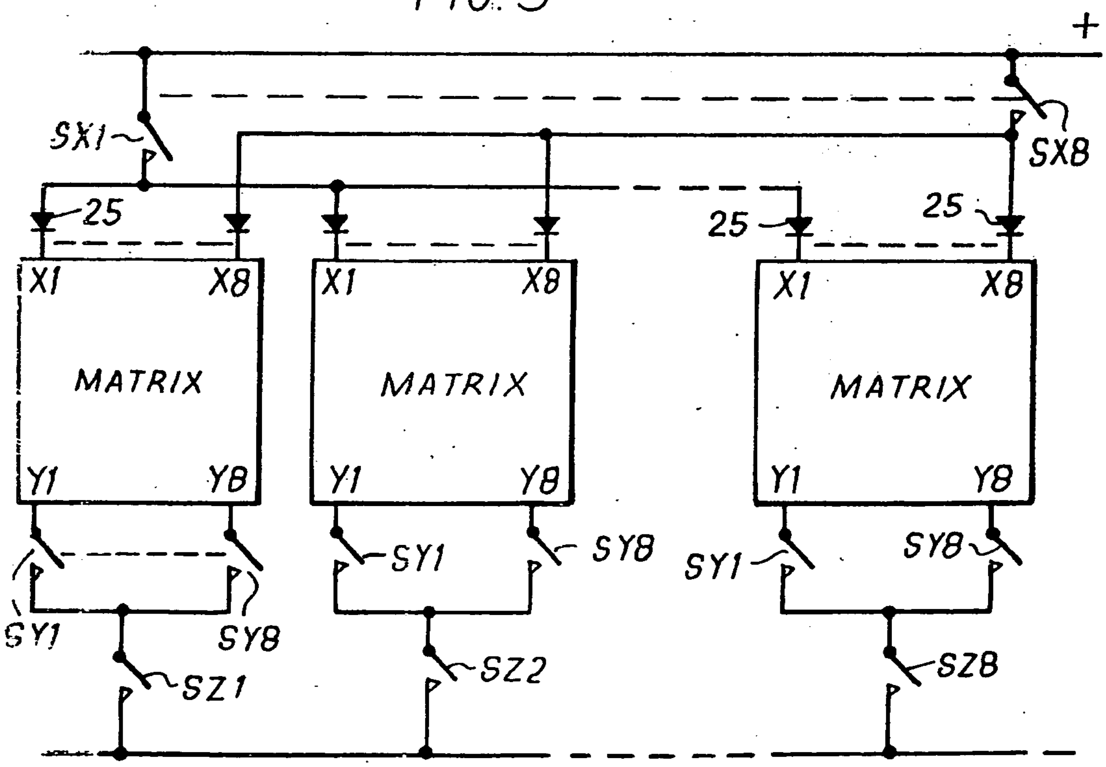

FULL
PRINT DENSITY
ZERO
20
21
22
100°C
120°C
TEMPERATURE
POWER
P/4
P

FIG. 5


+
SX1
SX8
25
25
25
X1
X8
MATRIX
Y1
Y8
X1
X8
MATRIX
Y1
Y8
X1
X8
MATRIX
Y1
Y8
SY1
SY8
SY1
SY8
SY1
SY8
SZ1
SZ2
SZ8

SPECIFICATION

Thermal printing device

The present invention relates to a thermal printing device comprising a line of resistors and a matrix drive arrangement whereby individual resistors can be energised to effect printing of dots on a heat sensitive paper. The line of resistors is commonly called a print head. If the paper is moved past the head in the direction at right angles to the line of resistors it is possible to print characters or graphical matter by selecting the instants at which the resistors are individually energised.

To obtain an adequate resolution the resistors are pitched very finely, e.g. at 50 per centimetre. To make this possible, the resistors are normally printed by a thick film technique. If the head is say 5 or 10 cm. long, there are around 250 or 500 resistors in all. The large number of resistors requires the use of a matrix drive arrangement. For example, 256 resistors can be driven by a 16×16 matrix arrangement and 512 resistors can be driven by an $8 \times 8 \times 8$ matrix arrangement or a 32×16 matrix arrangement. In the case of a two-dimensional matrix arrangement, the drive lines may be referred to as the X and Y lines. A three-dimensional arrangement is best throught of as a plurality of two-dimensional matrices with shared X and Y drive and selection between matrices in accordance with Z lines.

If, in a two-dimensional matrix, a resistor is connected between an X line and a Y line at every matrix intersection, any given resistor may be energised by completing a circuit through one X line and one Y Line. However various measures have had to be taken to deal with sneak current paths through non-selected resistors, as explained more fully below. One technique requires a diode to be inserted in series with every resistor. The problem with this is that a large number of diodes is required and bonded connections have to be made to every diode. Manufacture is therefore labour-intensive and costly.

Another known technique provides an individual switch such as a thyristor for every resistor. The gate electrode of every thyristor is connected through two resistors to a combination unique to that thyristor of one X line and one Y line, thereby providing AND logic for turning on the thyristor. Modules of say ten resistors, each with its thyristor and two gate resistors, are formed as integrated circuit chips which are bonded to a ceramic substrate. The problems with this technique are the need to provide as many thyristors as there are resistors and the difficulty of aligning the chips accurately enough to get all resistors uniformly in line.

The object of the present invention is to overcome the problem of sneak current paths in a way which does not lead to the manufacturing difficulties which are encountered in the known techniques.

The invention is based upon an appreciation of two factors. The first is that a mathematical analysis has shown that, in the worst possible case, the total current through an unselected resistor which lies in several sneak current paths is substantially smaller than the current through the selected resistor. If the matrix is square and of reasonable size, say at least 8×8, the worst possible case is a current of $I/2$ where I is the current through the selected resistor. Power, i.e, the heating effect of the current, is proportional to the square of current and therefore, for a square matrix, the worst possible case gives a power $P/4$ dissipated in an unselected resistor where P is the power dissipated in the selected resistor.

The second factor is that the density versus temperature characteristic of suitable heat sensitive papers has a sharp transition (approximating a step function) between no effect on the paper and production of a dot of full print density. The transition may be referred to as the knee of the characteristic and may occupy a range of 20°C (e.g. from 100°C to 120°C) or an even smaller range of say 5°C for certain papers.

The invention makes use of these two factors by connecting the resistors directly between the X and Y lines without incorporation of any means designed to eliminate sneak current paths. It is arranged that the power dissipated in a selected resistor heats the resistor to well above the knee of the density versus temperature characteristic and that the power dissipated in a non-selected resistor by virtue of sneak current paths can only, in the worst possible case, heat the resistor to a temperature well below the knee.

The invention thus overcomes the problem of sneak current paths in a very simple manner. The head can be manufactured simply and cheaply because only the resistors themselves and the X and Y lines have to be laid down. The relatively small number of X and Y lines makes it possible for the head proper to be connected to the drive current sources in a way allowing replacement of the heat alone in the case of a fault therein.

The only slight drawbacks are firstly that only one resistor can be energised at a time, whereas known devices with diodes allow all desired resistors in one matrix row to be energised simultaneously. At worst this imposes a restriction on the speed of printing, a restriction which will not matter in the slightest in many applications.

Secondly, there is a wastage of power in the sneak current paths. If the power drawn by the

selected resistor is P, the total power drawn by the device rises to NP/2 for the case of a square N × N matrix. The cost of the wasted power is an insignificant factor. So long as N is not too large, say not larger than 16, existing drive sources can cope with the increased power without any modification. We have tested an experimental 64—resistor head with an 8 × 8 drive matrix and achieved fully satisfactory operation. The wasted power does not lead to any deleterious rise in the mean temperature of the head. If necessary a heat sink can be used to conduct heat away from the head and get rid of it by convection and radiation cooling.

When the invention is employed with three-dimensional matrix drive arrangements diodes are desirable in some of the drive lines to the constituent two-dimensional matrices, as explained below. The number of diodes is however very much smaller than the number of resistors.

The scope of the invention is defined in the subsequent claims. Further explanation of the invention is given, by way of example, with reference to the accompanying drawings, in which:–

Figure 1 illustrates an embodiment of the invention and shows the sneak currrent paths existing therethrough,

Figures 2 and 3 shows the circuits at individual matrix intersections in two known arrangements,

Figures 4 shows characteristic curves typical of heat sensitive papers, and

Figure 5 is a schematic illustrations of how the invention may be extended to a three-dimensional matrix drive arrangement.

For simplicity, Fig. 1 shows only a 4 × 4 matrix with sixteen resistors 10 connected one at each intersection between one of four X drive lines 11 and four Y drive lines 12. In practice a larger matrix will be employed. The resistors are shown in their electrical positions at the matrix intersections. Physically, the resistors are in a line and the lines 11 and 12 are configured accordingly. The X lines 11 are connected to the positive terminal of a source of energising power through individual switches 13 shown as electro-mechanical switches but consisting in practice of transistor switches (so-called drivers). On switch 13a is shown closed; all the others are open. Similarly the Y lines 12 are connected to the negative supply terminal through individual switches 14 of which only switch 14a is closed.

It follows that the resistor labelled 10a has been selected and that it passes a current I = V/R where V is the supply voltage and R is the resistance of each resistor 10. One sneak current path is shown by the arrowed track in broken lines and passes through the resistors 10b, 10c and 10d, the resistor 10c carrying current in the "wrong" direction. Although not shown in the same way, it can be seen that there is another sneak path through the resistors denoted 10b, 10c, 10e, 10f and 10g, 10c and 10f being traversed the wrong way. The cumulative effect of all possible sneak paths is to give a maximum current in a resistor 10 other than the selected resistor 10a of I/2.

All sneak paths involve traversal of at least one resistor the wrong way. For this reason one known technique for stopping sneak current paths consists in inserting a diode 16 in series with every resistor as shown in Fig. 2. The other known technique discussed above is shown in Fig. 3 where each resistor 10 has its own energising circuit through a thyristor 17 with gate resistors 18. The lines 11 and 12 are now switched between loopical levels "O" and "1" to turn on the thyristor 17 only when both associated lines are at "1" level.

The simplicity of Fig. 1 compared with Figs. 2 and 3 is apparent. Severe manufacturing difficulties are eliminated and the head proper (resistors 10 and lines 11 and 12) can be a module distinct from one or more modules incoporating the switches 13 and 14. For an N × N matrix, there are only 2N connections to the head module.

Fig. 4 shows the print density versus temperature characteristic 20 of a suitable heat sensitive paper. The knee 21 of the characteristic occurs between 100°C and 120°C. Characteristic 22 has an even sharper knee. The temperature rise of a resistor energised briefly with power P is approximately proportional to the product of P and the duration of the energisation, which duration will be taken to the constant. Fig. 4 also illustrates how it can be arranged that power P causes the temperature to lie well above the knee 21 whereas power P/4 causes the temperature to lie well below the knee. The P and P/4 temperatures will vary somewhat in dependence upon the quiescent temperature of the resistors but the separation between the P and P/4 temperatures can be sufficient to allow for a reasonable range of variation of quiescent temperature.

Fig. 5 illustrates extension of the invention to an 8 × 8 × 8 arrangement with 512 resistors. Eight 8 × 8 matrices 24, each with resistors 10 directly connected between X and Y lines as in Fig. 1 each have X lines X1 to X8 and Y1 to Y8. The 64 X lines are connected through switches SX1 to SX8 to the positive supply terminal, all lines X1 being controlled by SX1 and so on. It is necessary to provide inter-matrix isolation by 64 diodes 25 in the 64 X lines. It is to be noted and only 64 and not 512 diodes are needed. The 64 Y lines are connected through 64 switches SY1 to SY8, where there are 8 ganged SY1 switches, one per matrix, and so on. The switches SY1 to SY8 for each matrix are connected through a corresponding one of eight Z switches SZ1 to SZ8, one per matrix.

When one X switch, one Y switch and one Z switch are closed a single resistor in one matrix 24 is selected. Sneak currents flow in other resistors in the same matrix (but in no other matrices) but their heating effect is insufficient to mark the heat sensitive paper for the reasons already explained.

Finally, the results of mathematical analysis of a general matrix like that shown in Fig. 1 but with x X lines any y Y lines may be given. The largest sneak current is in any non-selected resistor I_s the larger of:

$$I_{s1} = I_o \left(\frac{x-1}{x+y-1}\right) \text{ and } I_{s2} = I_o \left(\frac{y-1}{x+y-1}\right)$$

where I_o is the current in the selected resistor.

The total current drawn by the matrix is

$$I_t = I_o \left(\frac{xy}{x+y-1}\right)$$

Both formulae apply for any one X switch 13 closed and any one Y switch 14 closed. Values are tabulated for some matrices as follows:

Matrix Size	I_t/I_o	I_{s1}/I_o	I_{s2}/I_o
8 × 8	4.27	.467	.467
16 × 16	8.25	.484	.484
16 × 32	10.89	.319	.659
8 × 64	7.21	.099	.887
24 × 24 (576)	12.26	.489	.489
16 × 24 (384)	9.85	.385	.590

For a very large square matrix, where 1 is negligable compared with x and y, we have:

$$I_{s1} = I_{s2} = I_o/2$$

and

$$I_t = I_o\, x/2$$

Such a matrix cannot be used in practice because of the excessive value of I_t. Some of the tabulated examples will be ruled out in most cases for the same reason, e.g. the 24 × 24 matrix. The 8 × 64 matrix may well be ruled out by the value of $I_{s2} = 0.887\ I_o$. In such situations resort may be had to the kind of arrangement illustrated in Fig. 5. As a rough guide, any individual matrix without diodes is best kept to a square or near square matrix of size in the range 8 × 8 to 16 × 16.

CLAIMS (13 Oct 1978)

1. A thermal printing device comprising a line of resistors arranged for heating a heat sensitive paper, each connected between one of a group of first conductors and one of group of second conductors, the combination of first and second conductor corresponding to each resistor being unique thereto, and switching means enabling a circuit to be completed by way of any selected first conductor and any selected second conductor and the resistor connected therebetween, and wherein the resistors provide direct, resistive, bidirectional connections between the first and second conductors.

2. A method of effecting printing on heat sensitive paper utilizing a line of heating resistors connected in a matrix drive arrangement whereby any resistor may be selected for energisation, wherein sneak currents are allowed to flow through non-selected resistors and the heat sensitive paper is such that the temperature of a selected, energised resistor suffices to make a mark on the paper whereas the temperature of a non-selected resistor traversed by a sneak current is insufficient, in the worst possible case, substantially to make a mark on the paper.

CLAIMS (10 Oct 1979)

1. A thermal printing device comprising a line of N resistors arranged for heating a heat sensitive paper, each connected between one of a group of n first conductors and one of group of m second conductors, where n, m, and N are integers and $N = n \times M$, the combination of first and second conductor corresponding to each resistor being unique thereto, and switching

means enabling a circuit to be completed by way of any selected first conductor and any selected second conductor and the resistor connected therebetween, and wherein the resistors are linear resistors which provide direct, resistive, bidirectional connections between the first and second conductors.

2. A method of effecting printing on heat senstive paper utilizing a line of N heating linear resistors connected in a $n \times m$ matrix drive arrangement whereby any resistor may be selected for energisation, where n, m and N are integers and $N = n \times m$, wherein sneak currents are allowed to flow through non-selected resistors and the heat sensitive paper is such that the temperature of a selected, energised resistor sufficies to make a mark on the paper whereas the temperature of a non-selected resistor traversed by a sneak current is insufficient, in the worst possible case, substantially to make a mark on the paper.

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